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INSULATION SYSTEMS, FEASIBILITY STUDY AND DEVELOPMENT

Final Report of Phase I
NBTL Project A-634
SR-007-04-02, Task 2757
26 June 1965
by
J. F. Boyle

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PHILADELPHIA, PENNA 19112

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

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TABLE OF CONTENTS

	Page No.
ABSTRACT	i
SUMMARY PAGE	ii
ADMINISTRATIVE INFORMATION	iii
REFERENCES	iii
REPORT OF INVESTIGATION	1
Introduction	1
Evaluation of Current Specification System	1
Proposed General Solution	2
Proposed Solution for Felts and Blankets	3
Proposed Specification for Felts and Blankets	5
Discussion	5
Conclusions	6
Recommendations	6

APPENDIX

A - Specification List - Felts and Blankets

B - Specification Characteristics Under Performance Criteria

C - Individual Specification Requirements Under Performance Criteria

D - Sample Specification for Felts and Blankets

ABSTRACT

This report presents the results of a study conducted to determine the feasibility of effecting a simplification in the current specification system covering thermal insulating materials.

The study presents a plan to reduce a large number of single specifications to a small group of generalized specifications by elimination of all but essential testing procedures and by the standardization of test requirements.

A general specification covering insulation felts and blankets, with emphasis on performance characteristics, is presented as an illustration of the proposed format.

SUMMARY PAGE

The Problem

Conduct a study to determine the feasibility and/or the desirability of developing a general specification or standard for thermal insulating materials, placing greater emphasis on performance characteristics.

Findings

A review of the present system of thermal insulation specifications reveals that a certain amount of duplication exists in the area of property and performance tests. Since the specifications have the common goal of retardation of heat transfer, the specifications lend themselves to consolidation or grouping.

Recommendations

Based on a study of the specifications covering thermal insulation, it is recommended that:

1. It be considered not feasible or practical to prepare a single general specification covering all thermal insulation materials.

2. It be considered feasible to reduce the present number of specifications by the preparation of a small group of general specifications.

3. The general specifications take a form such as that proposed to insure greater emphasis on the characteristics of material performance.

4. Phase II of the project be initiated to establish the proper tests and/or parameters necessary to insure required performance characteristics.

ADMINISTRATIVE INFORMATION

This project was authorized by BUSHIPS ltr SR-007-04-02 Ser 634A/871 of 4 Sept 1964. The cost of the project is chargeable to Allotment No. 24995 Approp. 17 x 1319.2451. The Navy Index Number is SR-007-04-02, Task 2757.

References

(a) "Insulation Systems, Feasibility Study and Development", Progress Report No. 1 of NBTL Project A-634 (SR007-04-02, Task 2757) of 15 Dec 1964

(b) "Insulation Systems, Feasibility Study and Development", Progress Report No. 2 of NBTL Project A-634 (SR007-04-02, Task 2757) of 16 Mar 1965.

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National Bureau of Standards, Code 154.

REPORT OF INVESTIGATION

INTRODUCTION

This report constitutes Phase I of the project to reevaluate the specifications covering thermal insulation materials in use by the Navy. Specifically, an investigation has been made to determine the feasibility of reducing the present multi-specification system to either a single document or to a small group of generalized specifications.

Since the chief function of all thermal insulation materials is in the retardation of heat transfer, duplication arises in the testing of material properties and performance characteristics. Investigations were made to determine if duplication of testing is extensive enough to warrant consolidation of the system.

In addition to a desire for consolidation, a major aim of the project is to place greater emphasis on those characteristics that affect the performance of materials in service.

EVALUATION OF CURRENT SPECIFICATION SYSTEM

Initial work of this investigation, covering a survey of current specifications, was reported by references (a) and (b). These reports list all the characteristics presently measured and the frequency with which each test occurs. From this study, it was determined that duplication of testing occurs to a certain degree; however, it is not extensive enough to warrant the preparation of a single all-encompassing specification. The diversity of products and the peculiarities of application of products covered by these specifications preclude the preparation of such a single document.

PROPOSED GENERAL SOLUTION

It is feasible, as reported in reference (b), to consider those specifications that lend themselves to grouping. For example, all felts and blankets can be considered in one category, pipe coverings in another, block insulation in another, etc.

In addition to the above grouping, greater emphasis can be placed on performance characteristics by listing the presently measured attributes under one of the following categories:

1. HEAT TRANSFER REQUIREMENTS
2. INSTALLATION REQUIREMENTS
3. SERVICE LIFE REQUIREMENTS
4. SAFETY AND CORROSIVITY REQUIREMENTS
5. MISCELLANEOUS REQUIREMENTS

By such a grouping, a major aim of the project is realized, i.e., the placing of greater stress on those characteristics that are most meaningful from a performance standpoint. These categories emphasize:

Why a given material qualifies as a heat transfer retardant.

What are the physical installation requirements.

Where is the service location.

How will the material withstand the rigors of service.

With this type of listing, only those characteristics that are necessary to insure the requirements of a particular category need be measured.

While the above procedure may be considered applicable to other specifications under this project, for purposes of the Phase I feasibility study, the

remainder of this report is limited to those specifications covering Felts and Blankets.

PROPOSED SOLUTION FOR FELTS & BLANKETS

Since specifications covering felts and blankets constitute twenty-five percent of all the specifications of thermal insulating materials, they were examined in detail for applicability to the proposed format.

Appendix A lists existing specifications considered in the category of felts and blankets.

Appendix B illustrates the grouping of measured characteristics of the subject specifications on a performance basis.

Appendix C lists the requirements as they presently appear in the subject specifications.

A detailed study was made of the data in Appendix B to determine the significance of each measured characteristic. Conversely, examination was also made to determine any situation where test requirements are inadequate for proper protection of the Navy's interests. By this procedure, only the necessary areas of testing would be employed. The following observations are made in reference to Appendices B and C:

1. Heat Transfer Requirements

a. The most meaningful test in this category is that of thermal conductivity which is a measure of how the insulation functions as a heat transfer medium. Since thermal conductivity is dependent on fiber diameter, density, thickness, binder content, shot content, asbestos fiber content, and asbestos type, the effects of these attributes are implicit in the thermal conductivity measurement.

Therefore, the question is raised as to the necessity for measuring anything other than the thermal conductivity.

b. Thermal conductivity requirements (k factor) should be set to cover the complete temperature range specified for insulation use. Table I, Appendix D lists the requirements as they appear in the present specifications and it is evident that k factors are not stipulated for all possible operating temperatures.

2. Installation Requirements

The characteristics in this category are of primary importance from an installation viewpoint. As such, they are of secondary importance once the installation is completed. The present specifications are complicated by a wide diversity of dimensional requirements.

3. Service Life Requirements

a. Present specifications do not always define service temperature limitations.

b. Certain specifications have requirements for vibration resistance. However, a suitable test for this characteristic does not exist at this time. An adequate test should be developed under the Phase II investigation.

4. Safety & Corrosivity Requirements

Some non-uniformity exists in the following areas:

a. Acceptable limits for alkalinity control.

b. Proper criteria for non-combustibility and fire resistance.

PROPOSED SPECIFICATION FOR FELTS & BLANKETS

Appendix D shows a proposed specification for felts and blankets. Its intent is to present a single specification for these materials in the format previously discussed.

It will be possible, under this specification, to test for certain characteristics by existing procedures; however, for others, proper qualification tests will have to be developed. For instances where individual materials may require specific tests, addendums may be included to the general specification.

Phase II of this project will be concerned with the development of the proper test procedures and parameters necessary for the protection of the Navy's interest in these areas.

DISCUSSION

Since the existing specifications have been prepared over a period of time, certain inconsistencies have arisen. Test procedures for the same characteristic in the various specifications are not always uniform, and in some cases, repetitious. This condition is shown in Appendices A and B. Such inconsistencies lead to confusion. Therefore, it is desirable that test methods be standardized and whenever possible, ASTM test methods should be used. ASTM methods, already stipulated for many tests, possess the advantage that they have wide acceptance as standard procedures.

CONCLUSIONS

1. Upon approval, the general specification as described for Felts and Blankets will also be applied in Phase II of this project to other types of insulation materials. The advantages of such a system are, simplification and standardization of requirements on a performance basis. An added advantage of this system is that new and improved materials for insulation purposes may be incorporated more easily since the emphasis is on performance rather than material composition.

2. It would be to the Navy's advantage for the ultimate insulation material to be of minimum thickness, minimum density, and minimum k value. While the specification now states maximum acceptable values for these items, there does not now exist any incentive for suppliers to produce material better than the specification. It would be desirable for the Navy to develop such an incentive; in the case of the subject materials, it may take the form of a combination of thermal conductivity and density considerations. The validity of this concept can be explored in the Phase II of this project.

RECOMMENDATIONS

It is recommended that simplification of the present specification system can best be achieved by grouping specifications of a similar nature, as illustrated by Appendix D. By this procedure, a small group of generalized specifications can be prepared with particular emphasis placed on performance characteristics. It is further recommended that the development of testing procedures and performance requirements be finalized in Phase II of this project.

APPENDIX A

SPECIFICATION LIST
(FELTS AND BLANKETS)

HH-I-542	Insulation Felt, Thermal, Mineral Wool (Low Temperature)
MIL-I-2818	Insulation Blanket, Thermal, Fibrous Material
MIL-I-15091	Insulation Felt, Thermal, Asbestos Fiber
MIL-I-16022	Insulation Blanket, Thermal, Fibrous Glass
MIL-I-16411	Insulation Felt, Thermal, Glass Fiber
MIL-I-16688	Insulation Felt, Thermal, Fibrous Mineral (Semi Rigid Lt.Wt.)
MIL-I-20077	Felt, Asbestos, Roll
MIL-I-22023	Insulation Felt, Thermal and Sound Absorbing, Fibrous Glass Flexible
MIL-I-23128	Insulation Blanket, Thermal Refractory Fiber, Flexible
MIL-I-15475	Insulation Felt, Thermal, Fibrous Glass, Semi Rigid

APPENDIX B

SPECIFICATION CHARACTERISTICS UNDER PERFORMANCE CRITERIA (FELTS AND BLANKETS)

HEAT TRANSFER REQUIREMENTS

(a) fiber diameter
(b) thickness
(c) density
(d) binder content
(e) thermal conductivity
(f) shot content
(g) moisture absorption
(h) asbestos fiber content
(i) asbestos type
(j) organic sizing content

INSTALLATION REQUIREMENTS

(a) length
(b) width
(c) thickness
(d) density
(e) flexibility
(f) supporting members
(g) weight
(h) tensile strength

SERVICE LIFE REQUIREMENTS

(a) binder content
(b) resistance to smoldering
(c) fire resistance
(d) vibration resistance
(e) compression strength
(f) moisture absorption
(g) loss in weight
(h) fusing temperature
(i) stability
(j) tensile strength
(k) flammability
(l) change on heating
(m) deterioration of fiber

APPENDIX B (Cont'd)

SAFETY OR CORROSIVITY REQUIREMENTS

(a) alkalinity
(b) sulfur content
(c) fire resistance
(d) organic sizing content

MISCELLANEOUS REQUIREMENTS

(a) material or composition

APPENDIX C

INDIVIDUAL SPECIFICATION REQUIREMENTS UNDER PERFORMANCE CRITERIA (FELTS AND BLANKETS)

I - HEAT TRANSFER

Fiber diameter

SPEC. NO.	SPEC. REQUIREMENTS
MIL-I-15475	Avg. of Fibers to be .0008" with no fiber greater than .0015
MIL-I-16022	" " " " " .00010-.00055" " " " " .00060
MIL-I-16411	" " " " " .00030-.00040" " " " " .00050
MIL-I-16688	" " " " " .0001-.0003"
MIL-I-22023	" " " " " .00025"
MIL-I-23128(A)	Avg. to be not greater than .00015"
" " " (B)	" " " " " " .00035"

Thickness

MIL-I-542	1" to 4" in 1/2" increments
MIL-I-2818	as specified
MIL-I-15091	3/4", 1"
MIL-I-15475	1", 1-1/2", 2", 3", 4"
MIL-I-16022	1/2", 3/4", 1"
MIL-I-16411	Class I, 3/4", 1", 1-1/2" Class II, 1/2", 3/4"
MIL-I-16688	1", 1-1/2", 2", 3", 4", 5"
MIL-I-20077	1/8", 1/4"
MIL-I-22023	1/2" to 4" in 1/4" increments
MIL-I-23128	1/4", 3/8", 1/2", 3/4", 1", 1-1/2", 2"

Density

MIL-I-542	Not greater than 11#/ft^3
MIL-I-2818	" " " 12#/ft^3
MIL-I-15091	" " " 12#/ft^3
MIL-I-15475	" " " 3#/ft^3
MIL-I-16022	" " " 1.5#/ft^3
MIL-I-16411(I)	" " " 9#/ft^3
" " " (II)	" " " 7.5#/ft^3
MIL-I-16688	" " " 2.25#/ft^3
MIL-I-20077	Between 4.5 and 5.5#/ft^3

MIL-I-22023	Class 1 - Not greater than 0.5#/ft^3									
" " "	Class 2 - " " " 0.75#/ft^3									
" " "	Class 3 - " " " 1.0#/ft^3									
" " "	Class 4 - " " " 1.5#/ft^3									
" " "	Class 5 - " " " 2.0#/ft^3									
" " "	Class 6 - " " " 3.0#/ft^3									
MIL-I-23128(A)	" " " 4.0#/ft^3 nor less than 2.5#/ft^3									
" " " (B)	" " " 7.2#/ft^3 " " " 5.0#/ft^3									

Binder content

MIL-I-2818	Shall not exceed 1.5% of weight of fibrous mineral component									
MIL-I-22023	" " " 30% " " " " " "									

Thermal conductivity (Btu/ft^2/hr/$^\circ$F/inch)

MIL-I-542	k = 0.25 @ 25°F		
	" = 0.28 @ 50°F		
	" = 0.31 @ 75°F		
MIL-I-2818	" = 0.55 @ 450°F		
MIL-I-15091(A)	" = 0.65 @ 350°F		
(B)	" = 0.45 @ 75°F		
MIL-I-15475	" = 0.28 @ 75°F		
	" = 0.35 @ 150°		
	" = 0.61 @ 350°		
MIL-I-16022	" = 0.27 @ 75°F		
MIL-I-16411(1)	" = 0.45 @ 300°F		
" " "	" = 0.56 @ 500°F		
" " "	" = 0.70 @ 700°F		
" " " (1I)	" = 0.35 @ 300°F		
" " "	" = 0.45 @ 500°F		
" " "	" = 0.60 @ 700°F		
MIL-I-16688	" = 0.28 @ 75°F		
MIL-I-22023(1)	" = 0.27 @ 25°F	0.29 @ 50°F	0.31 @ 75°F
(2)	" = 0.27 @ 25°F	0.29 @ 50°F	0.31 @ 75°F
(3)	" = 0.25 @ 25°F	0.26 @ 50°F	0.28 @ 75°F
(4)	" = 0.24 @ 25°F	0.25 @ 50°F	0.26 @ 75°F
(5)	" = 0.22 @ 25°F	0.23 @ 50°F	0.24 @ 75°F
(6)	" = 0.21 @ 25°F	0.22 @ 50°F	0.23 @ 75°F
MIL-I-23128(A)	" = 0.38 @ 400°F	0.55 @ 600°F	-
" " " (B)	" = 0.50 @ 400°F	0.80 @ 600°F	1.05 @ 900°F

Shot content

MIL-I-2818	Shall not contain more than 20% by weight
MIL-I-15475	" " " " " 20% by weight
MIL-I-16688	" " " " " 10% " "

Moisture absorption

MIL-I-542	Shall not gain more than 2% by weight
MIL-I-2818	" " " " " 1.25% " "
MIL-I-16688	" " " " " 37% " "

Water absorption

MIL-I-15091(A)	Not greater than 80% by volume
" " " (B)	" " " " 20% " "

Asbestos fiber content

MIL-I-15091(A)	Asbestos fiber shall not be less than 95%
" " " (B)	" " " " " " " 90%
MIL-I-20077	" " " " " " " 98.5%

Organic sizing content

MIL-I-20077 Shall not be more than 1.5%

Asbestos type

MIL-I-15091 Asbestos fiber shall be amosite.

II - INSTALLATION

	Dimensional Requirements			DENSITY
SPEC. NO.	LENGTH	WIDTH	THICKNESS	(lbs/ft^3)
MIL-I-542(I-Sheet)	48"	24"	1.1$\frac{1}{2}$,2,3,4	
" " " (I-Roll)	30", 48"	12", 24"	1"-4" in $\frac{1}{2}$ increments	11
" " " (II-Sheet)	100', 200'	18",36",54", 72"	1/2",1,1-1/2",2"	

	LENGTH	WIDTH	THICKNESS	DENSITY lbs/ft^3
MIL-I-2818		NOT SPECIFIED		
MIL-I-15091	Not Specified	3-60"	3/4", 1"	12
MIL-I-15475	48"	24", 30"	1,1-1/2",2",3",4"	4
MIL-I-16411(I)	25'	60"	3/4", 1,1-1/2"	9
" " " (II)	25'	60"	1/2", 3/4"	7.5, 15
MIL-I-16022	200')		1/2")	
" " "	200')	72"	3/4")	1.5
" " "	100')		1")	
" " "	25')		1")	
MIL-I-16688	36"	30"	1",1-1/2",2",3",4",5"	3.25
MIL-I-20077	100'	36"	1/8", 1/4"	3.25, 4.1
MIL-I-22023	50,100,200'	36",48",54", 72"	1/2"-4" in 1/4" increments	(I) 0.5
" " "	"	"	"	(II)0.75
" " "	"	"	"	(III)1.0
" " "	"	"	"	(IV) 1.5
" " "	"	"	"	(V) 2.0
" " "	"	"	"	(VI) 3.0
MIL-I-23128(A)	36",48",96"	12",24",36", 42"	1/4",3/8",1/2", 3/4"	2.25-4
" " " (B)	288",300",600"		1",1-1/2",2"	5.0-7.2

Flexibility

MIL-I-542 I No rupture at 90° bend
" " " II Rupture at 90° bend
MIL-I-22023 No rupture at 90° bend
MIL-I-23128 " " " 90° "

Supporting members

MIL-I-2818 Shall be 1" wire mesh with wire approximately .036" in dia. or expanded metal lath.

Weight

MIL-I-15475 4 ounces/sq.ft./1" thick

Tensile strength

MIL-I-16411 Before and after heating to 1200°F, shall be 5 lbs/in^2
MIL-I-23128(A) (1200°F) - 1.0 lbs/ft^3
" " " (B) (2000°F) - 0.1 lbs/ft^3

III SERVICE LIFE

Resistance to Smoldering

MIL-I-16022 No smoldering after contact with hot poker @ 1450°F/1 hr.
MIL-I-22023 " " " " " " " " "

Fire resistance

MIL-I-20077 No smoking or flame, and only minor discoloration after contact with bunsen burner flame.
MIL-I-22023 To be rated incombustible or fire retardant after flame testing.
MIL-I-542 Sect VI of CS-131

Vibration resistance

MIL-I-2818 Shall not sag or settle after test
MIL-I-15091 " " " " " " "
MIL-I-15475 " " " " " " "
MIL-I-16411 " " " " " " "
MIL-I-22023 " " " " " " "

Compression resistance

MIL-I-23128 50 lbs/ft^2

Binder content

MIL-I-2818 Shall not exceed 1.5% of the weight
MIL-I-22023 " " " 30% " " "

Water absorption

MIL-I-15091(A) Not greater than 80% by volume
" " " (B) " " " 20% " "

Loss in weight

MIL-I-16022	Shall not exceed	3%	after heating to	600°/30 min.
MIL-I-16688	" " "	5%	" "	" 600°/30 min.
MIL-I-20077	" " "	16%	" "	" 1800°/1 hr.
MIL-I-23128(A)	" " "	1%	" "	" 1200°/24 hr.
MIL-I-23128(B)	" " "	2%	" "	" 2000°/24 hr.

Fusing Temperature

MIL-I-15475	Shall not be less than	1250°F
MIL-I-16411	" " " " "	1300°F

Stability

MIL-I-16411 No change after subjection to saturated steam at 225 lbs. for 16 hours.

Tensile strength

MIL-I-16411	Before and after	1200°F	shall not be less than	5.0 lbs/in^2
MIL-I-23128(A)	" "	1200°F	" " " " "	1.0 lbs/in^2
" " " (B)	" "	2000°F	" " " " "	0.1 lbs/in^2

Change on heating

MIL-I-23128(A)	Conformance with requirements after heating at	1200°F/24 hrs.
" " " (B)	" " " " "	at 2000°F/24 hrs.

Deterioration of fiber

MIL-I-23128(A)	Maximum after shaking -	5%
" " " (B)	" " " -	30%

IV SAFETY AND CORROSIVITY

Alkalinity

MIL-I-2818	Shall not exceed	0.60%	as	Na_2O
MIL-I-15475	" " "	0.60%	"	"
MIL-I-16022	" " "	0.60%	"	"
MIL-I-16411	" " "	0.20%	"	"
MIL-I-16688	" " "	0.60%	"	"
MIL-I-22023	" " "	0.60%	"	"

Sulfur content

MIL-I-2818 Fiber shall not contain more than 0.5% sulfur

Organic sizing content

MIL-I-20077	Shall not be more than 1.5%

Fire resistance

MIL-I-20077	No smoking, flame, and only minor discoloration after burning in Bunsen flame
MIL-I-22023	Test more elaborate than with MIL-I-20077
MIL-I-542	In accordance with Sect. VI of CS-131

V MISCELLANEOUS REQUIREMENTS

Material or Composition

MIL-I-542	Mineral wool felt-insulating refrigerated spaces
MIL-I-2818	Fibrous mineral insulation blanket-hot surface of machinery and equipment
MIL-I-15091	Asbestos fiber felt for thermal insulation
MIL-I-15475	Fibrous glass felt-ship boiler
MIL-I-16022	Fibrous glass blanket-ventilation systems-ducts of heated and unheated air
MIL-I-16411	Glass fiber insulation felt-turbines
MIL-I-16688	Mineral insulation felt-cold storage or refrigerated spaces
MIL-I-20077	Asbestos roll felt
MIL-I-22023	Fibrous glass felt
MIL-I-23128	Refractory fiber blanket-thermal control at 1200° and 2000°C

APPENDIX D

Sample Specification
for
Felts and Blankets

1. SCOPE AND CLASSIFICATION

1.1 Scope

This specification covers thermal insulation for high and low temperature service requirements such as refrigeration ducts and equipment to prevent sweating and frosting, hot surfaces of machinery and equipment, boiler uptakes, ventilation systems, etc.

1.2 Classification

1.2.1 Types - Insulation shall be of the following types as specified:

Type I - Insulation Felt-Thermal - A semi-rigid insulation furnished in sheets or cut pieces and composed of inorganic fibers with or without added binder.

a. Mineral wool

b. Asbestos fiber

c. Fibrous glass

Type II - Insulation Blanket-Thermal - Flexible insulation composed of inorganic fibers with or without added binder or support.

a. Refractory fiber

b. Fibrous mineral

1.2.2 Forms - The insulation shall be of the following types as specified:

a. Flexible sheet

b. Semi-rigid sheet

c. Felted rovings

d. Felted laminates

1.2.3 Sizes - Standard commercial sizes shall be procured. For non-standard sizes, order next larger commercially available size as per section 2.3.1.

2. REQUIREMENTS

2.1 Materials - Materials shall be as described in 1.2.1.

2.2 Heat Transfer - The heat transfer qualities of insulation materials shall be determined by the measurement of the thermal conductivity of the material.

2.2.1 Thermal Conductivity - The thermal conductivity shall be determined by the Guarded Hot Plate procedure as described in ASTM-C-177. Various materials covered by this specification including density values are listed in Table I (Phase II will provide data for all conditions up to maximum allowable temperature for a given material).

2.3 Installation

2.3.1 Dimensions - The following standard commercial sizes shall apply:

Length

Flexible	50, 100, and 200 feet
Non Flexible	30 and 48 inches

Width

Flexible	24", 36", 48", and 72"
Non Flexible	12", 15", and 24"

Thickness

Flexible	1/2", 1", 1½", 2", 3", and 4"
Non Flexible	1", 1½", 2", 2½", 3", 3½", and 4"

2.3.2 Flexibility - All materials listed as flexible must show no rupture or visible cracking when tested by the following procedure: (Phase II will set details of test procedure along the lines of that presently stated in MIL-I-22023B)

2.3.3 Supporting Members - Fibrous mineral insulation requiring supporting members shall use 1" wire mesh with wire approximately .036" diameter or expanded metal lath.

2.3.4 Tensile Strength - Determine minimum strength requirements for various fibers at service temperatures. Also, develop proper testing procedure for measurement of tensile strength. This will be developed during Phase II of this project.

2.4 Service Life

2.4.1 Binder Content - Phase II will determine if this may be eliminated in favor of a vibration test since the function of the binder is for physical strength.

2.4.2 Resistance to Smoldering - Present test employs a hot poker in contact with insulation material. Investigate relativity of test as employed to actual hazardous conditions.

2.4.3 Fire Resistance - Phase II will investigate the suitability of using test as detailed in MIL-I-22023B. In addition, studies will be made to determine what materials require testing.

2.4.4 Vibration Resistance - Develop test method to simulate environmental effects. The vibration test in MIL-I-23128 at the present time requires 100 hours.

2.4.6 Fusing Temperature - Fibers must not show any evidence of melting or fusing when heated for one hour at the maximum allowable service temperature.

2.4.7 Stability - Phase II will define those materials requiring stability in a saturated steam atmosphere. The suggested test for this characteristic is as detailed in MIL-I-16411C.

2.4.8 Change on Heating - Phase II will investigate the necessity for determining material stability after subjection to maximum allowable service temperature.

2.5 Safety and Corrosivity - This category includes those items that might present safety or corrosion problems to personnel and/or equipment.

2.5.1 Chloride Content - At the present time, no test procedure exists. However, in light of stress corrosion cracking of stainless steel, allowable limits for chloride should be developed in Phase II.

2.5.2 Alkalinity - The alkalinity expressed as Na_2O shall not exceed 0.60% (The test for alkalinity shall be as described in MIL-I-2818A).

2.5.3 Sulfur - Phase II will determine what materials should have a sulfur restriction. The maximum allowable sulfur content will be 0.5%, its determination will be by a method to be defined.

2.5.4 Fire and Flame Resistance - Tests similar to that described in MIL-I-22023B shall be set for all non-glass fibrous material, as well as for all materials containing a binder. Passing criteria shall be the same for all materials tested.

GENERAL NOTE

If any of the foregoing tests have only isolated applicability, they will be handled in addenda to the general specification.

TABLE I
THERMAL CONDUCTIVITY REQUIREMENTS
(k values)

	Temp. Limitation, °F	Density lbs/ft³	25°	50°	75°	100°	150°	200°	300°	350°	400°	450°	500°	600°	700°	900°
Mineral Wool		11	0.25	0.28	0.31											
Asbestos Fiber (Plain)		12								0.65						
Asbestos Fiber (Water Repellant)		12			0.45											
Refractory Fiber	1200	3									0.38			0.55		
Refractory Fiber	2000	5									0.50			0.80		1.05
Fibrous Mineral		12										0.55				
Fibrous Glass (Semi-Rigid)		3			0.28		0.35			0.61						
Fibrous Glass (Felted Rovings)	1200	9							0.45				0.56		0.70	
Fibrous Glass (Laminated)	1200	7.5							0.35				0.60		0.60	
Fibrous Glass (Flexible)	400	0.75	0.26	0.28	0.30	0.32		0.43								
Fibrous Glass (Flexible)	400	1.0	0.24	0.26	0.28	0.30		0.39								
Fibrous Glass (Flexible)	400	1.5	0.23	0.24	0.26	0.28		0.35								
Fibrous Glass (Flexible)	400	2.0	0.22	0.23	0.24	0.25		0.31								
Fibrous Glass (Flexible)	400	3.0	0.21	0.22	0.23	0.24		0.30								

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13. ABSTRACT

A study has been conducted to determine the feasibility of effecting a reduction in the current specification system covering thermal insulation materials. A plan is presented to reduce the present system of specifications to a small group of general specifications in a format designed to emphasize performance characteristics. This format is illustrated by a sample specification covering felts and blankets used in thermal insulation.

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Security Classification

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	ROLE	WT	ROLE	WT	ROLE	WT
Insulation						
Materials Specification						
Felts						
Blankets						
Feasibility						

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Project No. A-634
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J. F. Boyle
25 June 1965 27 pp.
UNCLASSIFIED

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